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TITLE

ANTIBACTERIAL MATERIAL

DESCRIPTION

Technical field

The present invention relates to an anti-bacterial material to be used for removing micro organisms such as bacteria, fungi or virus from surfaces, such as organic surfaces including skin and including wounds, construction surfaces including building surfaces, furniture surfaces and automotive surfaces, as well as for removing microbes in air by being present in a filter form.

The object of the present invention is to obtain an anti-microbial material, which can be used for primarily removing bacteria, fungi and/or virus from different surfaces and substrates without wetting or contaminating the surface with different antibacterial agents.

A second object is to obtain a material, which has a microbicidal effect as well.

Background of the invention

It is generally known to prepare materials of different structures and thereby providing them with a liquid, which may contain an anti-bacterial effect as it may contain an anti-bacteriostatic or bactericidal substance.

Quite often the liquid is an alcohol, such as ethanol or isopropanol, which in itself is bactericidal, or at least bacteriostatic.

The problem is the wiping around with such a material, which will contaminate surfaces around the primary target to be cleansed, and complete removal of bacteria will thus not be obtained.

The use of wet materials is not always appropriate as the liquid may damage the surface treated, a treated wound may be hurting from concentrated alcohol or even damages may occur due to sensitivity.

US 6,258,455 discloses an anti-microbial ultra-microfilament cloth having one yarn of fine fiber of 1.0 denier or less, and one yarn having an antimicrobial fiber, which yarns

are engaged with each other. The antimicrobial fiber consists of a cellulose fiber having been acetate treated to obtain antimicrobial properties. The problem solved is to prevent propagation of bacteria and fungi in cleansing cloths as common cloths just remove such microbes. From a general standpoint of view it is indicated that such cloths just spread the microbes around, and do not absorb them. By having an antimicrobial effect such microbes should be killed.

An ultra microfiber consisting of polyamide and polyester is said to be superior conventional fibers due to its finess and due to its triangular cross-section. The cross-section provides for a mechanical lifting off of the microbes. It is also said to have a positive charge for attracting the microbes, which charge is due to the polyamide. The fiber will, however, provide a possibility for continued propagation of the microbes. To attain antimicrobial activity triclosan is embedded in the acetate fiber, whereby triclosan has an ability of penetrating the cell walls of thin walled cells.

EP-A-1,091,676 discloses a skin care device with a cleansing tool comprising a padding configuration consisting of at least in part of microfiber tissue. Thus the cleansing effect is related to the microfiber as such.

DE-A-19,839,505 relates to a cleansing cloth being a knitted fabric with woven zones providing a cleansing surface with projecting microfiber loops or piles produced in an automatic production line.

EP-A-0 286 741 relates to a polyamide yarn provided with built-in antibacterial capacity whereby an adhesive on the fiber surface of an antimicrobial agent consisting of an organosilicon, quaternary ammonium salt compound and a surfactant is present thereon.

WO 01/96433 relates to the use of polymers containing urethane and/or urea groups for the modification of surfaces, whereby the polymers are used on particulate materials, line-shaped, planiform or three-dimensional entities.

JP 200003284 relates to surface modification of antibacterial agents for fibers to be able to incorporate the antimicrobial agent in the fiber without causing problem to the fiber when knitted, woven or otherwise used.

US-A-4,847,089 relates to a cleansing and disinfecting composition comprising an alkaline per-salt and a positively charged phase-transfer agent and absorbent materials,

such as sponges, impregnated therewith. The positively charged phase-transfer agent is preferably a quaternary ammonium salt. The composition may be formulated as a cream, a bulk powder, a solution or tablets. It may also be incorporated in wipes, sponges and brushes. In one embodiment, one surface of the impregnated sponge is an abrasive material. The compositions of the invention according to USP 4,847,089 find utility in health care, as disinfectants in surgical applications, and as cleansing and decontaminating agents. Specific uses include skin cleansing and disinfecting.

In the cleaning of surfaces including skin, other soft surfaces, as well as hard surfaces it is often of utmost interest and importance to remove microbes in form of bacteria and fungi or viruses by mechanical means and/or by using an antimicrobial agent that kills or makes the microbes passive. The bacteria of interest to become removed are *Escherichia coli, Staphylococcus aureus* and different *Streptococcus* strains. *E. coli* may give raise to different gastro-intestinal illnesses, while *S. aureus* may cause troublesome infections, like certain Streptococci.

It is also known that most cells are electrically charged and this has been the basis of the present invention.

Summary of the present invention

The present invention thus primarily relates to a antimicrobial material for absorbing and retaining microbes, including bacteria, fungi and/or virus, characterized in that it has a positive charge that creates an electrical field strength of at least 100 V/m, preferably the positive charge creates an electrical field strength of at least 150 V/m, more preferably the positive charge creates an electrical field strength of at least 200 V/m.

In a preferred embodiment the material consists of a fibrous, non-woven material.

In a further preferred embodiment the material consists of a fibrous, woven material.

In another preferred embodiment the material consists of a naturally occurring fiber.

In a further preferred embodiment the material consists of an inorganic fiber.

In another preferred embodiment the material consists of an organic, polymeric fiber.

In a further preferred embodiment the surface consists of an organic polymeric composite fiber.

In another preferred embodiment the material is in the form of a layered structure.

In another further preferred embodiment the material is in the form of a layered structure having a second treating ingredient(-s) on a side opposite to the positively charged side.

In a preferred embodiment the inventive material is to be used in health care, including hospital care.

Detailed description of the present invention

By identifying the specific surface charge being antimicrobial the invention is independent of chemistry and chemical processes, but the invention is based on electrostatic interaction between a charged surface and the surface of microbial cell thereby providing an antimicrobial effect. This makes it possible to produce a number of chemically varied entities and manufacturing processes taking into account the specific application of the product prepared.

By using electrostatic interaction together with cell surfaces a number of different intracellular as well as extracellular processes are generated, such as electrostatic attraction with intracellular charges and the binding of a microbe onto a charged surface, mediation of transmembrane ion channels, and mediation of metabotrophic receptors and intracellular signal pathways, as well as other routes of action.

The level of electrostatic charge to attract microbes was primarily determined in a series of test.

Test 1.

E. coli and *S. aureus* strains were used in the test to be described below. The bacteria, one type in each test, are suspended in a physiological saline solution (0.9 % NaCl). Glass substrates were covered with aluminium foil to be able to apply an electrical field over the bacterial suspension applied to the substrate. The substrate and aluminium foil are connected to an electric source having constant-regulated voltage, and is brought under a light microscope for analysis. Different voltages in the range of 0 to 40 V are applied. The movements of the bacteria suspended are studied. In order to differentiate between filed dependent movements and other types of movements the polarity is

changed. Different voltages were applied over the substrate. The following results were obtained.

Voltage	Observations
0-3 V	No influence on the movements of the bacteria. However, a movement perpendicular to the electrical field was observed, which probably was due to an increase of temperature.
4 V	Evident threshold level of influencing the movements of bacteria parallel to the electrical field lines In spite of polarity changes the bacteria strive towards the positive pole.
5-40 V	As for 4 V but more powerful movements. Even perpendicular movements increase.

The field strength at the point observed depends on the geometry of the observed position on the substrate relative the electricity conducting Al-poles. The field strength estimated at the point under observation was about 200 V/m at 4 V. Field strengths in the range of 100 V/m have an evident threshold effect in this test. The relative dielectricity constant of the solution was not considered.

It was observed that there was no difference between the bacteria strains tested.

Test 2.

Further tests were conducted using treated surfaces to provide for an electrical charge great enough to attract microbes. Chemically modified surfaces consisting of glass fiber filters and sterile plasters were used. The glass fiber substrate and the sterile plasters were modified by spreading 1 ml of 3-aminopropyl-triethoxy silane over the material surface for 5 min. The substrates were then placed in a heating cabinet to obtain a reaction between the EtO-Si-groups of the chemical and M-OH groups of the substrates. The chemically modified surfaces were exposed for 10 s to S. aureus and diphtheroidal rods in a nutrient solution (PBS). A cautious drainage took place for 20 s whereupon the substrates were rapidly pressed against a cultivation plate (agar). Cultivation took place in a heating cabinet for 24 hrs. The samples were read and photographed. Cultivation from the modified surfaces was 40 % lower than cultivation from non-modified surfaces.

Test 3.

Six glass fiber surfaces were modified in the same way as described in Test 2. The different surfaces differ from each other with regard to surface charge and type of modification. The chemicals were used in relative concentrations 1:1, 1:10, and 1:50.

The surface charge density for a dilution 1:1 can be expressed as if 2 ml 3-aminopropyl-triethoxy silane are attached to a macroscopic surface of 1 dm^2. The active surface is, however, probably considerably larger due to the surface enlargement obtained by the fiber structure of the material used.

The chemistry differed with regard to the outer end of the molecule. In the first group cases the molecule was ended with $-N^+(CH_3)_3$, and in the second group cases (Test 3) with $-NH_2$ groups. A substantial difference is thus the charge at neutral pH.

The tests have been carried out using 3-(trimethylammonium)propyl triethoxy silane and 3-aminopropyl-triethoxy silane, but also other substances can be used for obtaining a positive charge, such as other compounds attachable to the substrate and containing a free amino group, or a substituted amino group.

The different surfaces were exposed to a bacterium suspension of E. coli for 10 s. Drainage of surplus amount of liquid was carried out, whereupon the surfaces were rinsed with physiological saline solution for 20 s. The surfaces were allowed to dry before an electron microscopy examination took place. The result was somewhat difficult to read due to the drying as the cells dry out and their three-dimensional structure get lost. Certain detection is made in the form of traces after cell walls. Single cells have their structure left.

A second test was made whereby no drying was carried out. Electron microscopy examination was carried out immediately. Felts A, B. and C were all treated using 3-(trimethylammonium)propyl triethoxy silane, and Wovens A, B, and C were treated with 3-aminopropyl triethoxy silaneThe results obtained are given below.

Substrate	Conc.	Observation I	Observation II
Felt A	1:10	Only single bacteria cells can be detected. "Prints" of dried cell walls are, however, noticed.	
Felt B	1:1	As above	
Felt C	1:50		A large amount of bacteria was observed.
Felt, neg[1)]			Only single cells can be detected

Woven A	1:10	Only single cells can be detected
Woven B	1:1	Only single cells can be detected.
Woven C	1:50	Only single cells can be detected.
Woven neg[1]		Only single cells can be detected.

[1] neg means untreated clean surface used as reference.

The results obtained provide for the following understanding. In Observation I residues of bacteria are seen on all felt surfaces. No significant difference is seen, however, between the different preparations. This can be interpreted as concentration differences at the preparation of the surface i) does not give raise to significant differences in the ability of attracting bacteria, ii) that the preparations in spite of different handling does not significantly differ with regard to surface structure/charge density, or iii) that the concentration differences are incorrectly chosen with too small differences, or in the wrong range, alternatively.

Observation II gave a significant difference between Felt C and Felt neg which result is interpreted as an already low concentration difference at the preparation of the surfaces provides for surface characteristics enough to differ from an untreated surface. This observation is central for the interpretation of the results.

When it comes to the woven structures there are no significant differences noticed between samples A, B, C, and neg., respectively. The modifications of these structures thus have a low influence on the ability of attracting bacteria. This is explained by the uncharged surface structure. Structurally, these surfaces, however, show great similarity with the surfaces of the felt pieces.

The surfaces to be coated are any non-woven or woven structure of any natural structure, such as cellulose, cotton, wool, or other naturally occurring fibres or mixtures thereof, inorganic fibers, polymeric or mixed or otherwise composite fiber material in non-layered or layered, including multilayered form, as well as pure fiber web structures used for e.g., filtering purposes. Cellulose fibers are often used in non-woven tissue, even paper, like inorganic fibers, such as glass and stone fibers or fibrous calcium sulphate. Other naturally occurring fibers are often used as filaments in woven

materials. Polymeric fibers and composite fibers, such as carbon fiber, polyamide fiber, polyolefin fiber, polyester fiber, which can be used in a non-woven structure as well as in a woven structure.

In case of layered products one side thereof may be provided with a positively charged side that creates an electrical field strength of at least 100 V/m, while the other side comprises e.g., a wound cleansing preparation in the form of a saline solution, a wound healing preparation in the form of an ointment or more or less viscous liquid, or gel, possibly containing nourishing substances and/or growth factors, a skin lotion, a sun protecting lotion, a skin moisturing lotion, a skin "tanning" composition.

Other applications are as filtering aids in breathing masks or venting systems in prenatal incubators, buildings or vehicles, such as rail wagons, and cars, including trucks, where the fibers used for filtering the air are prepared for absorbing bacteria or virus, thereby eliminating access to the respiratory tract, e.g., in face masks for avoiding contamination of SARS, severe acute respiratory syndrome, virus or other types of viruses, such as influenza viruses. It has also been proposed for cleaning if possibly infected water, such as under field conditions.

Other applications are as surface cleansing cloths for hard or semi hard surfaces such as furniture, building walls and floors, sanitary equipment, and other equipment to prevent bacterial, fungal, or viral contamination. Thus so called miracle fibre cloths having a fibre of a particular triangular cross-section can be modified by positively charging the same in accordance with the present invention.

Other applications are stockings and socks to reduce bacterial and fungi growth in "hot" feet. Other applications are as incontinence diapers, napkins, handkerchiefs, wound compresses, plaster, surgical cloths, surgery clothing, and pre-surgery coverings. In applications concerning incontinence diapers the primary aim is to take care of odour-producing bacteria, which quite often occur in such situations. The material of the invention is also well suited for use under field conditions, as there is no volatile liquid present.

Surgical cloths can be used not only at surgery but also at the treatment of eczema and burn injuries, where the skin is sensitive to inflammation of microbes, in particular bacteria. Thus such cloths can be used for covering and/or sheets.

In all applications it is also a question of obtaining a microbicidal effect, i.e., a killing of any microbe attracted to the antimicrobial material of the invention.

The antimicrobial material of the invention can thus be used as filter, as cleansing cloth in health care including hospital care and medical treatment, in cosmetics, in general sanitarian care and maintenance. One example of a cleansing material is a dry cloth to be used by doctors, and nurses, or other personal in contact with different patients or patient groups, where there is a request for antibacterial cleansing between any new meeting with a patient, and where hitherto used alcoholic solutions tend to dry out the skin causing irritation and even supersensitivity.

CLAIMS

1. Antimicrobial material for absorbing and retaining microbes, including bacteria, fungi and/or virus,
   characterized in
   that it has a positive charge that creates electrical field strength of at least 100 V/m.

2. Antimicrobial material according to claim 1, wherein the positive charge creates electrical field strength of at least 150 V/m.

3. Antimicrobial material according to claim 2, wherein the positive charge creates electrical field strength of at least 200 V/m.

4. Antimicrobial material according to one or more of the preceding claims, wherein the material consists of a fibrous, non-woven material.

5. Antimicrobial material according to one or more of claims 1-3, wherein the material consists of a fibrous, woven material.

6. Antimicrobial material according to claims 1-5, wherein the material consists of a naturally occurring fiber.

7. Antimicrobial material according to claims 1-5, wherein the material consists of an inorganic fiber.

8. Antimicrobial material according to claims 1-5, wherein the material consists of an organic, polymeric fiber.

9. Antimicrobial material according to claims 1-5, wherein the surface consists of an organic polymeric composite fiber.

10. Antimicrobial material according to claims 1-9, wherein the material is in the form of a layered structure.

11. Antimicrobial material according to claims 10, wherein the material is in the form of a layered structure having a second treating ingredient(-s) on a side opposite to the positively charged side.

12. Antimicrobial material according to claims 1-11 to be used in health care, including hospital care.

13. Antimicrobial material according to claims 1-11 to be used in an air filter as a filtering mass.

14. Antimicrobial material according to claims 1-11 to be used in a water cleaning arrangement.

ABSTRACT

The present invention relates to a antimicrobial material for absorbing and retaining microbes, including bacteria, fungi and/or virus, whereby it possesses a positive charge which crates electrical field strength of at least 100 V/m, as well as certain uses thereof.